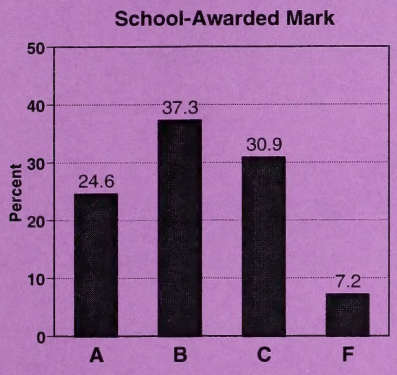
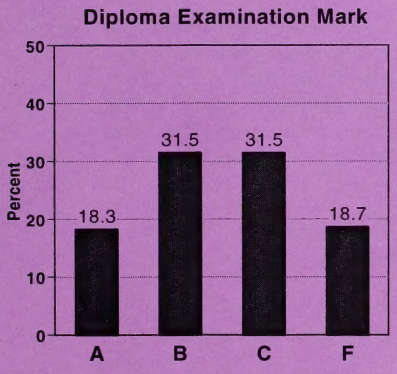
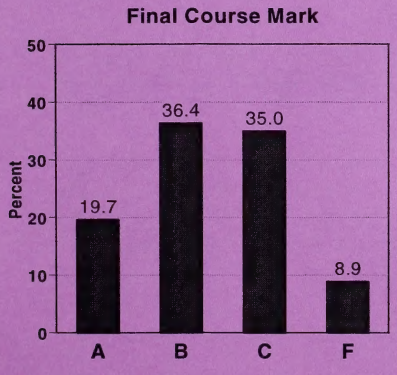
AL.1.128
C.2

Chemistry 30

Diploma Examination Results
Examiners' Report for January 1999







The summary information in this report provides teachers, school administrators, and students with an overview of results from the January 1999 administration of the Chemistry 30 Diploma Examination. This information is most helpful when used in conjunction with the detailed school and jurisdiction reports that are provided electronically to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined November, January, June, and August results is made available annually.

Description of the Examination

The Chemistry 30 Diploma Examination consists of 44 multiple-choice questions worth 55%, 12 numerical-response questions worth 15%, and two written-response questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 6 868 students in Alberta who wrote the January 1999 examination and received a school-awarded mark. The total number of students writing in the year has remained relatively stable. The November examination sitting decreased the number of students writing both January and June examinations from 1997 to 1998.

- 91.1% of the 6 868 students achieved the *acceptable standard* (a final course mark of 50% or higher).
- 19.7% of the students achieved the *standard of excellence* (a final course mark of 80% or higher).

Generally, student achievement in Chemistry 30 was good. The percentage of students who achieved the *acceptable standard* (91.1%) was slightly lower than was the percentage for January 1998 (93.2%). Most students demonstrated a good understanding of energy, oxidation-reduction and acid-base chemistry. Some students had difficulty on this exam with equilibrium concepts and multi-step calculations.

Approximately 51.9% of the students who wrote the examination were female. Of these, about 91.6% achieved the acceptable standard for a final course mark, compared with 90.6% of the male students. Approximately 19.3% of the female students achieved the standard of excellence, compared with 20.1% of male students. The average examination mark achieved by the female students was 63.7%, and the male students achieved an average mark of 64.3%.

Alberta
EDUCATION

Provincial Averages

- The average school-awarded mark was 68.6%.
- The average diploma examination mark was 64.0%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 66.6%.

Approximately 8.3% of the students who wrote the examination in January 1999 and received a school-awarded mark had previously written at least one other Chemistry 30 Diploma Examination during the January 1998 to January 1999 period. This subpopulation (572) achieved an examination average of 61.4%, compared with 64.0% for the population (6 296) who first wrote a Chemistry 30 examination in January 1999. The group of students who rewrote increased their overall average by 9.3%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students achieving the *acceptable standard* will obtain a mark of 50% or higher, and students achieving the *standard of excellence* will obtain a mark of 80% or higher. The Chemistry 30 Examination requires students to apply their understanding of concepts to new situations in a clear, concise, organized fashion and to respect the conventions of the mode of communication selected.

In the following blueprint, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score (out of 1) achieved by students who wrote the examination.

Questions are also classified by general learner expectations (GLE).

Knowledge:

GLE 1 Quantitatively Predicting Outcomes
GLE 2 Qualitatively Analyzing Systems
GLE 3 Relationships in Energy Transfer
GLE 4 Relationships in Electron Transfer
GLE 5 Relationships in Equilibrium Systems
GLE 6 Relationships in Proton Transfer

Skills:

SPC Scientific Process & Communication Skills

Science, Technology, & Society:

STS Science, Technology, & Society Connections

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
MC1	B	0.846		✔	✔					
MC2	C	0.729	✔		✔				✔	
NR1	40.8/44.0	0.860	✔		✔				✔	
MC3	C	0.617		✔	✔					✔
NR2	1.19	0.280	✔		✔				✔	✔
MC4	A	0.567		✔	✔				✔	✔
MC5	C	0.971	✔		✔				✔	
MC6	D	0.811		✔	✔					
MC7	D	0.837		✔	✔					✔
NR3	1321	0.522		✔	✔					
MC8	D	0.793		✔	✔					
MC9	A	0.623		✔	✔					
MC10	D	0.740		✔		✔			✔	✔
MC11	B	0.667	✔			✔			✔	✔
MC12	C	0.778		✔		✔			✔	
MC13	A	0.802		✔		✔			✔	✔
MC14	A	0.613		✔		✔			✔	
MC15	D	0.620		✔		✔				✔

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
MC16	C	0.296		✔				✔	✔	✔
MC17	A	0.908		✔		✔			✔	✔
MC18	D	0.537	✔			✔			✔	✔
MC19	A	0.501	✔			✔			✔	
MC20	B	0.820	✔			✔			✔	✔
MC21	A	0.767		✔		✔				✔
MC22	D	0.768	✔			✔			✔	✔
NR4	2.37*	0.908	✔			✔			✔	✔
NR5	3.04†	0.460	✔			✔			✔	✔
NR6	1.89	0.634	✔			✔			✔	✔
MC23	B	0.457	✔			✔			✔	
MC24	B	0.734		✔		✔				
NR7	4631	0.600		✔		✔			✔	
MC25	D	0.747		✔		✔			✔	✔
MC26	D	0.871		✔				✔		✔
MC27	A	0.882	✔			✔			✔	
MC28	B	0.444		✔		✔				
MC29	B	0.241	✔				✔			✔
MC30	B	0.454		✔			✔		✔	✔
NR8	2.64	0.277	✔				✔		✔	✔
NR9	8.52	0.568	✔					✔	✔	✔
MC31	C	0.809		✔				✔	✔	✔
NR10	34.5	0.173	✔				✔		✔	✔
MC32	D	0.588		✔			✔		✔	
MC33	C	0.761	✔					✔	✔	
MC34	D	0.827		✔				✔		
MC35	B	0.849	✔					✔	✔	
MC36	A	0.699		✔			✔		✔	
MC37	B	0.899		✔			✔			✔
MC38	C	0.874		✔				✔	✔	
MC39	A	0.685		✔				✔	✔	✔
MC40	D	0.857		✔				✔	✔	
MC41	B	0.543		✔				✔	✔	
MC42	C	0.793		✔				✔	✔	✔
NR11	6.51	0.926	✔					✔	✔	✔
NR12	3.26‡	0.636	✔					✔	✔	✔
MC43	C	0.740		✔				✔	✔	✔
MC44	A	0.697		✔				✔	✔	
WR1	—	0.568	✔(12)		✔(8)				✔(4)	✔(12)
WR2	—	0.508		✔(12)		✔(4)		✔(4)	✔(4)	✔(12)

*NR4: 0.80 if A was selected from MC22; 0.34 if B was selected; 0.13 if C was selected, and 2.37 if D was selected
†NR5: 12.5 if A was selected from MC22; 7.94 if B was selected; 12.5 if C was selected, and 3.04 if D was selected
‡NR12 = (NR11)/2 = 3.26

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

Machine scored:	37.9 out of 56
Multiple choice	31.1 out of 44
Numerical response	6.8 out of 12
Written Response:	13.1 out of 24
Question 1	6.8 out of 12
Question 2	6.1 out of 12

Raw Score Average for Machine-Scored Items and Written-Response Questions by General Learner Expectation

GLE 1	Quantitatively Predicting Outcomes	20.7	out of	34
GLE 2	Qualitatively Analyzing Systems	30.3	out of	46
GLE 3	Relationships in Energy Transfer	12.7	out of	20
GLE 4	Relationships in Electron Transfer	16.7	out of	25
GLE 5	Relationships in Equilibrium Systems	3.3	out of	7
GLE 6	Relationships in Proton Transfer	14.1	out of	20
SPC	Scientific Process & Communication Skills	33.0	out of	50
STS	Science, Technology, & Society Connections	33.8	out of	56

Multiple-Choice and Numerical-Response Questions

The following table gives results for four questions selected from the examination and shows the percentage of students in four groups that answered each question correctly. The comments following the table relate to some of the understandings and skills the students may have used to answer these questions.

Percentage of Students Correctly Answering Selected Machine-Scored Questions

	Question Number			
Student Group	**MC 13**	**MC 28**	**NR 8**	**NR 10**
All Students	80.2	44.4	27.7	17.3
Students achieving the *standard of excellence* (80% or higher, or A) on the whole examination	96.1	65.3	67.9	45.2
Students achieving the *acceptable standard* but not the *standard of excellence* on the whole examination	82.8	43.6	23.1	13.8
Students who have not achieved the *acceptable standard* (49% or less, or F) on the whole examination	56.1	26.9	3.8	1.6

13. Four metals represented by the symbols R, S, T, and V and their ions combine with each other in the following manner:

$S^{2+}_{(aq)} + 2\,T_{(s)} \rightarrow 2\,T^{+}_{(aq)} + S_{(s)}$

$R^{3+}_{(aq)} + T_{(s)} \rightarrow$ No Reaction

$2\,R^{3+}_{(aq)} + 3\,V_{(s)} \rightarrow 3\,V^{2+}_{(aq)} + 2\,R_{(s)}$

When the oxidizing agents are arranged from strongest to weakest, the order is

*A. $S^{2+}_{(aq)}$, $T^{+}_{(aq)}$, $R^{3+}_{(aq)}$, $V^{2+}_{(aq)}$

B. $V^{2+}_{(aq)}$, $R^{3+}_{(aq)}$, $T^{+}_{(aq)}$, $S^{2+}_{(aq)}$

C. $V_{(s)}$, $R_{(s)}$, $T_{(s)}$, $S_{(s)}$

D. $S_{(s)}$, $T_{(s)}$, $R_{(s)}$, $V_{(s)}$

---

28. An ionic solid dissolves and produces an equilibrium system. Which of the following statements about this system is **incorrect**?

A. The temperature of the solution is constant.

***B.** No solid is present at the bottom of the container.

C. Vigorous stirring does not dissolve more of the solid.

D. If the solution is heated, the amount of the solid that dissolves changes.

The following questions were selected for discussion because they exemplify the minimum requirements of the *acceptable standard* and of the *standard of excellence*.

Students achieving the *acceptable standard* but not the *standard of excellence* had no difficulty answering questions such as multiple-choice 1, 2, 8, 10, 11, 12, 13, 20, 21, 22, 33 and 44 and numerical-response 1.

For example, on **multiple-choice question 13,** most students (80.2%) were able to determine the order of reactivity of oxidizing agents from empirical data. A number of students (6.8%) did not understand the direction of the term strongest to weakest and therefore selected B as the correct response. A further 11.2% of the students were unable to identify the oxidizing agents and thus selected C or D as the correct response. The results from this question suggest that students that do not achieve the *acceptable standard* had difficulty analyzing reactivity data.

Most students achieving the *standard of excellence* had little difficulty answering questions such as multiple-choice questions 19, 23, and 28 and numerical-response questions 5 and 8.

For example, in **multiple-choice question 28**, 65.3% of students achieving the *standard of excellence* recognized that both reactants and products must be present in a system at equilibrium. Of the total population, many students (23.2%) did not understand the difference between the extent and the rate of dissolving for an equilibrium system, thus, they selected C as the correct response.

Numerical Response

8. The pH of a 0.28 mol/L $HN_{3(aq)}$ solution is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Answer: 2.64

Numerical Response

10. At a temperature of 300°C and a pressure of 40.5 MPa, 90.0 mol of $H_{2(g)}$ and 80.0 mol of $N_{2(g)}$ are injected into a reaction vessel. When equilibrium is established, 37.0 mol of $NH_{3(g)}$ are present. The number of moles of $H_{2(g)}$ present in this equilibrium mixture is _____ mol.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

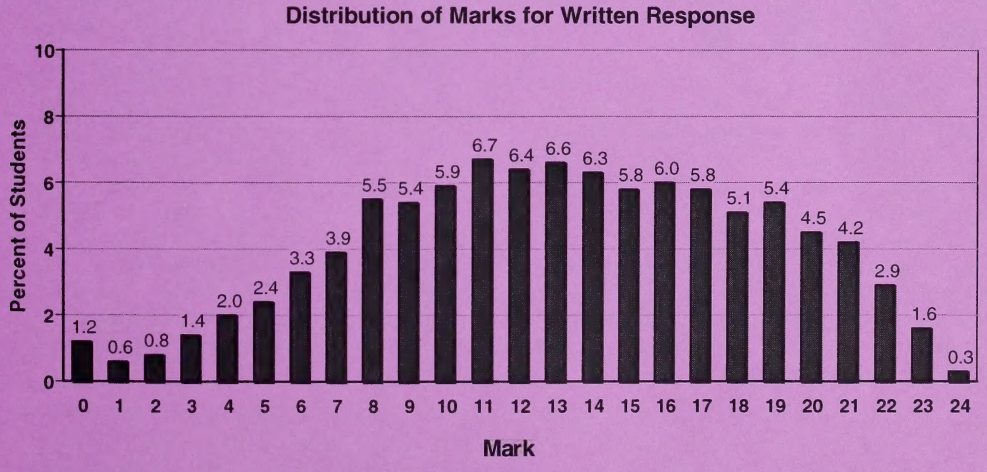
Answer: 34.5

In **numerical-response question 8**, 67.9% of students achieving the *standard of excellence* were able to correctly calculate the pH of a weak acid given a K_a and an equilibrium acid concentration. It should be noted that 31.6% of all students assumed the acid was strong even though the given K_a was lower than 1. These students, therefore, determined the pH by calculating the $-\log[H_3O^+_{(aq)}]$.

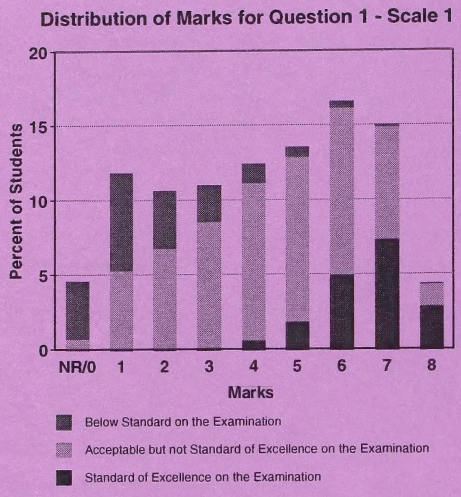
Numerical-response question 10 created difficulty for most students. Only 17.3% of all students were able to determine the number of moles of $H_{2(g)}$ present at equilibrium. A number of students (14.2%) correctly calculated the number of moles of $H_{2(g)}$ used, but they failed to subtract this value from the available moles of $H_{2(g)}$. Another 8.4% of the students did not consider the 3:2 coefficient ratio between the $H_{2(g)}$ and the $NH_{3(g)}$. They did, however, know they had to subtract the moles used from initial moles to determine the moles present at equilibrium.

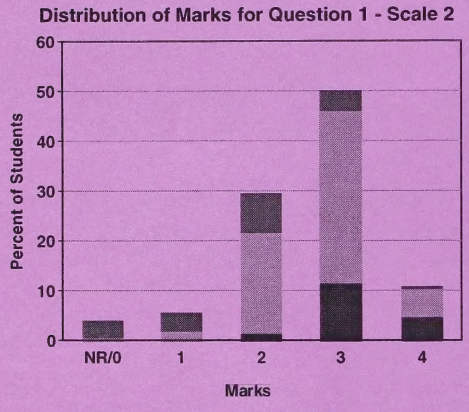
Written-Response Questions

Of the students who wrote the January 1999 examination, 1.2% received no marks for both written-response questions, 60.9% received a mark of 12 or higher out of 24, and 18.9% received a mark of 19 or higher out of 24 on the written response. The average for the written-response questions was 54.6%.



Written-response question 1 was designed to measure students' ability to perform enthalpy calculations for a respiration reaction and to communicate the enthalpy change on a potential energy diagram. Overall, students attempted all parts of the question. However, many students assumed that all combustion reactions produce gaseous water. Students who had difficulty balancing the combustion reaction failed to account for the oxygen in sucrose. Many students did not identify $H_2O_{(l)}$ as a product of respiration, which illustrated a lack of understanding of this combustion reaction.



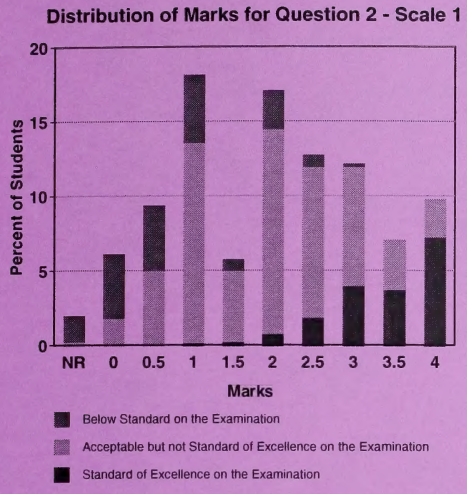


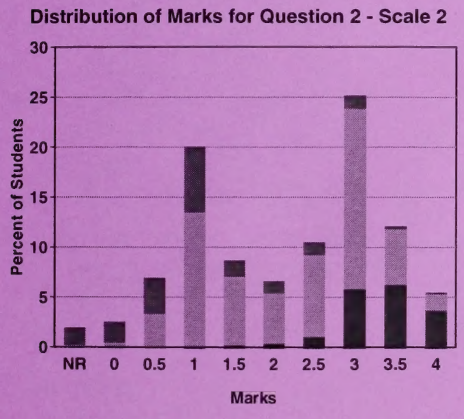
Students not achieving the *acceptable standard* averaged 1.7 out of 8 on the chemistry content and 1.7 out of 4 on the communication scale. Of the students who did not achieve the *acceptable standard* for this question, 8.0% did not attempt it. Overall, they averaged 3.4 out of 12 by demonstrating an understanding of how to detemine the average mass of the sugar cubes, the molar mass of sucrose, and the conversion of mass to moles. Most students were familiar with the $\Delta H = nH$ relationship. Some students confused molar enthalpy of formation with molar enthalpy of combustion. As a result, they did not use Hess' Law to determine the molar enthalpy of combustion for sucrose, nor did they provide a combustion equation. Students often drew an inappropriately labelled, untitled heating curve instead of an appropriate potential energy diagram. These students demonstrated a limited understanding of energy analysis and chemistry conventions. Students who did not achieve the *acceptable standard* consistently exhibited poor organizational and communication skills.

Students who achieved the *acceptable standard* but not the *standard of excellence* on the examination were expected to score from 6 to 9 for their combined mark. They averaged 4.3 out of 8 on the chemistry content scale and 2.7 out of 4 on the communication scale. Overall, they averaged 7.0 out of 12 by recognizing that there were three components to the question: the calculation of the molar heat of combustion for sucrose using Hess' Law, the determination of energy produced by a specific mass of sugar, and the graphical representation of molar enthalpy. These students consistently used Hess' law to calculate the molar heat of their combustion reaction. Most students did not identify liquid water as a product of respiration. Many students were unclear as to whether the molar heat of reaction was the same as the enthalpy change for a specific mass of reagent. The term "overall" in the first part of the question may have caused some confusion for these students. Many of them correctly calculated the molar enthalpy of combustion but then divided their answer by the molar mass of sucrose. This "over" calculation may be indicative of the need for these students to be more familiar with chemistry terminology. Many students graphed the heat of reaction for the average-sized sugar cube rather than the molar enthalpy of reaction for sucrose. Students who achieved the *acceptable standard* recognized the correct shape of the potential energy diagram for exothermic or endothermic changes. Generally, these students' responses were well organized, with units and significant digits correctly applied.

Students who achieved the *standard of excellence* were expected to score 10 or better out of 12. They averaged 6.5 out of 8 on the chemistry content scale and 3.2 out of 4 on the communication scale. Of these students, 16.1% attained a perfect score on the first scale, and 26.6% attained a perfect score on the second scale. These students demonstrated a working knowledge of enthalpy terminology based on the integration of the three aspects of the question. They mastered the calculations required and correctly articulated the calculated data on a potential energy diagram. It should be noted that only the better students used data for liquid water. These students demonstrated excellent attention to detail. The responses were well organized, clear, and concise.

On this 12-mark question, the average mark was 6.8, or 56.8%.


Distribution of Marks for Question 2 - Scale 1
Percent of Students
20
15
10
5
0
NR 0 0.5 1 1.5 2 2.5 3 3.5 4
Marks
Below Standard on the Examination
Acceptable but not Standard of Excellence on the Examination
Standard of Excellence on the Examination



Written-response question 2 was designed to measure students' ability to analyze laboratory data in order to identify unknown acid. Students were required to interpret three separate laboratory tests using the tables for Relative Strengths of Acids and Bases, Standard Electrode Potentials, Acid-Base Indicators, and the Solubility of Some Ionic Compounds in Water, which are found in the Chemistry 30 Data Booklet.

Overall, students were familiar with indicator colour–pH relationships. They recognized that an acid with a pH below 1.6 and a concentration of 1.0 mol/L was likely a strong acid. It was evident, based on student responses, that some students were unclear as to the number of reference tables required to address all aspects of the question. Students attempting to answer this question had difficulty integrating more than one chemistry data table. The most common error was the identification of a single replacement reaction producing hydrogen gas and an aqueous blue coloured copper(II) solution to support their acid choice. Few students included a calculation for the hydronium ion concentration. A number of students were under the impression that $10^{-pH} = K_a$. Students continue to use capitals indiscriminately for pH and have difficulty determining the correct number of significant digits for pH values.

Students who did not achieve the *acceptable standard* averaged 0.8 out of 4 on the chemistry content scale; thus, they received a content mark of 1.6 out of 8. These students averaged 1.1 on the communication scale. Of the students who failed this question, 8.9% did not attempt it. Their overall average was 2.7 out of 12 on this question. These students recognized that this was an acid–base question and attempted to identify the acid by interpreting more than one laboratory test. They utilized combinations of the Acid-Base Indicator, the Standard Electrode Potentials, and the Strengths of Acids and Bases tables to analyze the data provided. A number of students correctly determined the pH range of the methyl violet indicator and associated a low pH with a strong acid. Students were, however, unable to successfully connect all of the laboratory test results with appropriate reference tables to correctly identify the acid. Confusion over the strength of the acid resulted in acid choices below hydronium ion on the Relative Strengths of Acid and Bases table. Other students selected a mid-range pH of 0.8 or reversed the results and determined the pH of the acid as 1.6. Of those students who mistakenly determined that the pH was greater than 1.6, many consistently and correctly chose acids found below hydronium ion on the table. Students who only used the Standard Reduction Potential table to interpret the data frequently chose $HNO_{2(aq)}$ because it is the highest recognizable acid on the chart. When addressing the colour change and the evolved gas, these students associated the blue colour with copper ions and the evolved gas with hydrogen, because their analysis was based on an inappropriate Chemistry 20 single-replacement reaction of an acid with copper metal. These students failed to recognize that the acid identification involved an oxidation-reduction reaction. Almost no students in this group used the solubility table. They attempted to explain the silver ion solubility using the oxidation-reduction table position of the acid relative to silver metal. Students commonly selected $HI_{(aq)}$ as the acid since $I_{(aq)}$

National Library of Canada
Bibliothèque nationale du Canada
3 3286 51905201 9

was between $Cu_{(s)}$ and $Ag_{(s)}$ on the oxidation-reduction table. These students' responses illustrated fundamental chemistry misconceptions and were poorly organized with many errors in conventions.

Students who achieved the *acceptable standard* but not the *standard of excellence* were expected to score from 6 to 9 out of 12 for their combined mark. They averaged 1.9 out of 4 on the chemistry content scale that resulted in a content mark of 3.8 out of 8. These students averaged 2.2 on the communication scale. Overall, they averaged 6.0 out of 12 on the question because they could identify the unknown acid as either perchloric or nitric acid. They identified the acid by accurately interpreting the indicator–pH range and by using appropriate tables to correctly eliminate four of the strong acids. Students who selected perchloric acid typically ignored the formation of gas data. Many students correctly selected nitric acid due to the position of $NO_{3\,(aq)}^-$ on the oxidation-reduction table, between the silver and copper half-reactions, rather than by employing the multi-table analysis. Students correctly attributed the blue colour to copper(II) ions produced in a spontaneous reaction between the acid and copper metal. A number of students who assumed that the tests took place in a single reaction vessel, attributed the blue colour to a change in indicator colour resulting from a decrease in $[H^+_{(aq)}]$ as the copper metal reacted with nitric acid. Many students failed to distinguish between silver metal and silver ions and did not employ the solubility chart to interpret the data provided. Students who identified sulphuric acid as the unknown were not aware of the insolubility of $SO_4^{2-}{}_{(aq)}$ with silver ions. Students who achieved the *acceptable standard* but not the *standard of excellence*, generally presented a number of accurate, valid supporting arguments to substantiate their acid choice; however, they tended not to include either an appropriate calculation or equation. These students' responses were generally well organized with only minor errors in conventions such as significant digits for pH values.

Students who achieved the *standard of excellence* were expected to score 10 or better out of 12. They averaged 3.4 out of 4 on the chemistry content scale that resulted in a content mark of 6.7 out of 8. These students averaged 3.3 out of 4 on the communication scale. Of these students, 39.8 % attained a perfect score on the first scale and 20.8 % attained a perfect score on the second scale. Overall, they averaged 10.0 out of 12 on the question. Students achieving the *standard of excellence* did so because they could successfully identify the acid and support their choice with valid analyses and clearly stated inferences. Many students were able to calculate the $[H_3O^+_{(aq)}]$ from pH, identify the gas as $NO_{2(g)}$, and deal effectively with the silver precipitation information. They understood the pH–K_a relationship. Their analysis was generally logical and sequential. Although these students scored well on this question, small omissions in addressing all aspects of the question were noted. These students presented their answers in a succinct, well-written, and organized manner with minor errors.

On this 12-mark question, the average mark was 6.1 or 50.8 %.

For further information, contact Marlene McDonald (mmcdonald@edc.gov.ab.ca), Caroline Heppell (cheppell@edc.gov.ab.ca), or Corinne McCabe (cmccabe@edc.gov.ab.ca) at the Student Evaluation Branch at (780) 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.

Copyright 1999, the Crown in Right of Alberta, as represented by the Minister of Education, Student Evaluation Branch, 11160 Jasper Avenue, Edmonton, Alberta T5K 0L2. All rights reserved.

***Alberta educators** may reproduce this document for **non-profit educational purposes**.*